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Four non-yellow species of *Rhizocarpon* new to China

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Abstract—Four species of the lichen genus *Rhizocarpon* (*R. cinereonigrum*, *R. distinctum*, *R. sublavatum*, and *R. subpostumum*) are reported for the first time from China. Descriptions provide morphological and chemical characters and known distribution of each species.

Key words—lichen-forming fungi, *Rhizocarpaceae*, saxicolous, taxonomy

Introduction

Rhizocarpon Ramond ex DC. (*Rhizocarpaceae*, *Rhizocarpales*, *Lecanoromycetes*, *Ascomycota*) was established by de Candolle in 1805 (Ihlen 2004). *Rhizocarpon* can best be characterized by the crustose thallus, a usually distinct prothallus, black lecideine apothecia, *Rhizocarpon*-type and (1–)8-spored asci, and ellipsoid halonate hyaline to brown or olive-green ascospores that can be transversely septate or submuriform to muriform; *Rhizocarpon* species usually contain secondary compounds detectable by TLC (Fletcher & al. 2009; McCarthy & Elix 2014). *Rhizocarpon* includes about 226 species worldwide (Lücking & al. 2016, Davydov & Yakovchenko 2017), of which 44 species have been reported from China (Wei 1991; Abbas & Wu 1998; Aptroot & Sparrius 2003; Li & al. 2013; Zhao & al. 2013; Mahire & al. 2015; Wang 2015a,b,c, 2016). The genus is most diverse and abundant

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on siliceous rocks, with some species on calcareous rocks and a minority parasitic on other lichens in montane habitats and at temperate to higher latitudes (Ihlen 2004, McCarthy & Elix 2014).

This paper contributes further to our understanding of *Rhizocarpon* in China in the context of the Lichen Flora of China project. We have identified four species new to the country: *R. cinereonigrum*, *R. distinctum*, *R. sublavatum* and *R. subpostumum*.

Materials & methods

The specimens documented here are deposited in the Lichen Section of Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). Morphological and anatomical characters were examined under a COIC XTL7045B2 stereomicroscope and Olympus CX41 polarizing microscope. The thallus and medulla were tested with K (a 10% aqueous solution of potassium hydroxide), C (a solution of aqueous sodium hypochlorite), and I (Lugol's iodine) for identification. Lichen substances were identified using standardized thin-layer chromatography techniques (TLC) with solvent system C (Orange & al. 2010). The lichens were photographed with an Olympus SZX16 and a BX61 microscope with a DP72 lens.

Taxonomy

Rhizocarpon cinereonigrum Vain.,
Acta Soc. Fauna Flora Fenn. 53(1): 279 (1922) Fig. 1

Thallus crustose, with plane, contiguous areolae, dark greyish to dark brown, esorediate. Prothallus absent. Medulla white, I–. Apothecia black, round to rounded-angular, 0.3–0.5 mm diam., immersed to sessile, lecideine with a well-developed exciple, persistent, concave to flat. Proper exciple dark brown, with crystals partly dissolving in K; epihymenium dark brown, K+ violet-red; hymenium hyaline; paraphyses branched and anastomosing; hypothecium dark brown, K–. Asci 8-spored. Ascospores soon brownish green, 1-septate, with a halo, constricted at the septum when overmature, 28–38 × 12–18 μm. Conidiomata not seen.

Chemistry—Medulla K+ yellow, C–. Stictic acid detected by TLC.

Specimens examined: **CHINA. Sichuan**, **Kangding Co.**, Mt Zheduo, alt. 4200 m, on siliceous rock, 15 Oct. 2015, Weicheng Wang 20150702 (SDNU); **Luding Co.**, Moxi Town, Yajiagen, alt. 4000 m, on siliceous rock, 13 Oct. 2015, Weicheng Wang 20150665 (SDNU). **Yunnan**, **Shangri-La**, Mt Hong, alt. 4462 m, on siliceous rock, 18 Aug. 2018, Chunxiao Wang 20180633 (SDNU).

Distribution—Finland, Novaya Zemlya, and Greenland (Lynge 1932; Thomson 1997). New to China.

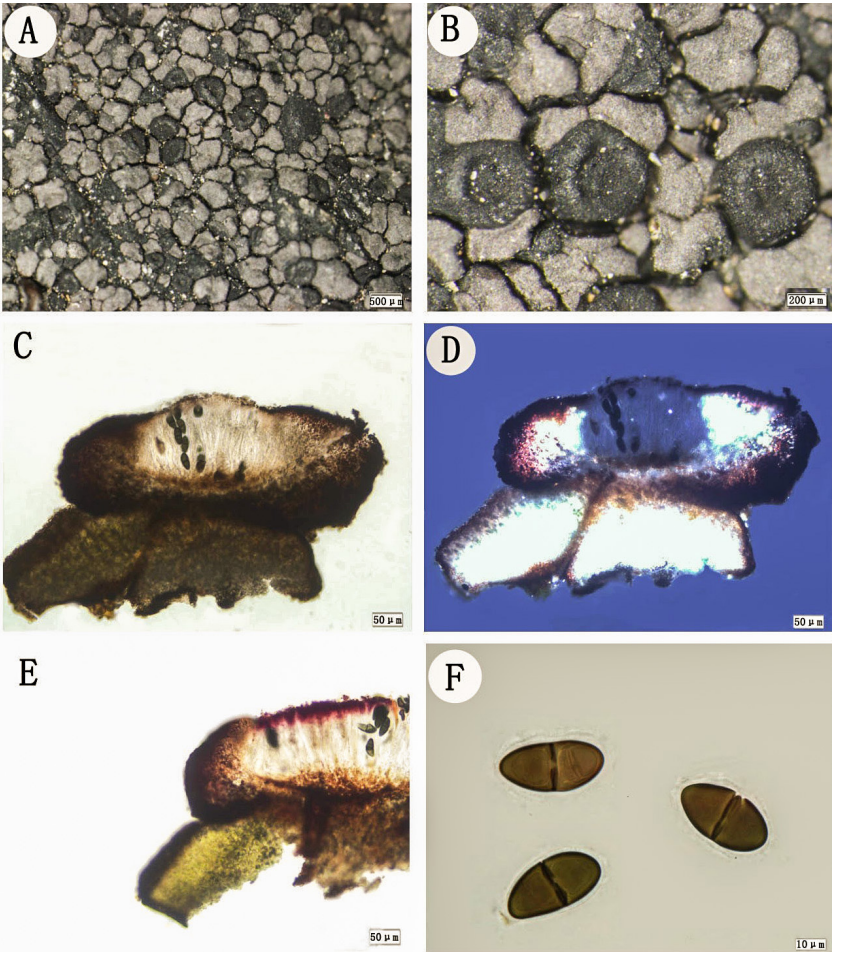

Fig. 1. *Rhizocarpon cinereonigrum* (SDNU – Wang 20150665). A: Thallus; B: Apothecia; C: Apothecium section; D: Crystals in exciple; E: K reaction; F: Ascospores.

Comments—Our specimens are similar to those described previously in the literature, except that the protologue description mentions a prothallus and convex apothecia (Thomson 1967, 1997). *Rhizocarpon cinereonigrum* is characterized by the dark greyish to dark brown thallus, epihymenium K+ violet-red, large 1-septate ascospores, and containing stictic acid. This species morphologically resembles *R. badioatrum* (Flörke ex Spreng.) Th. Fr. and

R. jemtlandicum Malme; however, *R. badioatrum* differs by containing ±stictic, ±norstictic; and diffractic acids, while *R. jemtlandicum* differs in its K–, olive to green-black epithecium (Timdal & Holtan-Hartwig 1988, Fletcher & al. 2009, Wirth & al. 2013).

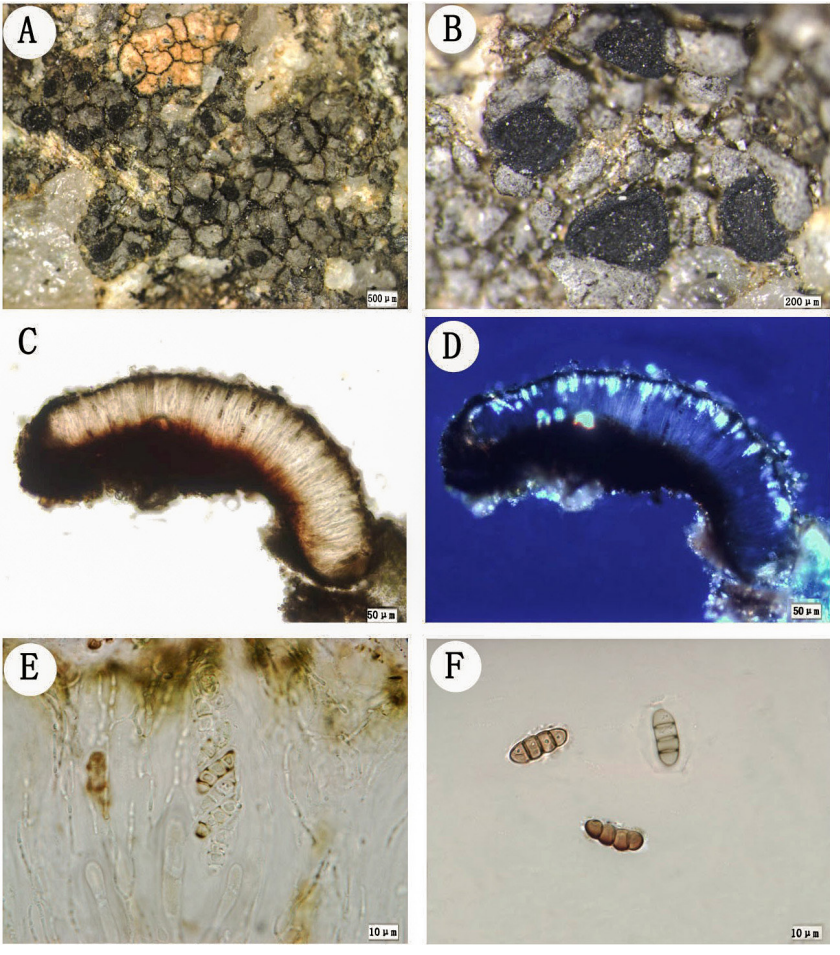

Fig. 2. *Rhizocarpon distinctum* (SDNU – Wang 20151607). A: Thallus; B: Apothecia; C: Apothecium section; D: Crystals in epihymenium; E: Ascus; F: Ascospores.

Rhizocarpon distinctum Th. Fr., Lichenogr. Scand. 2: 625 (1874) Fig. 2

Thallus areolate; areoles small, dark grey, contiguous or more rarely scattered, rounded to angular, convex. Prothallus black. Medulla white,

I+ blue. Apothecia lecideine, black, 0.3–0.5 mm diam., sessile, concave to flat; exciple thin, dark brown, persistent; epihymenium brown to olive-brown, K–, with crystals partly dissolving in K; hymenium hyaline; hypothecium dark brown. Asci 8-spored. Ascospores soon brown, 3-septate to submuriform with 4–6 cells, with a halo, 20–27.5 × 7.5–12.5 µm. Conidiomata not seen.

Chemistry—Medulla K+ yellow, C–. Stictic acid detected by TLC.

Specimen examined: **CHINA. Sichuan, Mt. Zheduo**, alt. 4000 m, on siliceous rocks, 15 Oct. 2015, Weicheng Wang 20151607 (SDNU).

Distribution—*Rhizocarpon distinctum* has been reported from Europe, British Isles, North America (eastern Canada), Antarctica, Novaya Zemlya, Australia, and New Zealand (Lynge 1932, Thomson 1997, Øvstedal & Smith 2001, Ihlen 2004, Fletcher & al. 2009, Galloway 2007, McCarthy & Elix 2014). New to China.

Comments—Our specimens match previously published descriptions, except for the presence of an epihymenium containing crystals partly dissolving in K (Ihlen 2004, Fletcher & al. 2009). *Rhizocarpon distinctum* is characterized by the amyloid medulla, 3-septate to submuriform ascospores, and the occurrence of stictic acid (Timdal & Holtan-Hartwig 1988, Thomson 1997, Øvstedal & Smith 2001, Ihlen 2004, Fletcher & al. 2009, McCarthy & Elix 2014). The small areoles and apothecia of *R. distinctum* are suggestive of *R. reductum* Th. Fr., *R. sublavatum* and *R. timdalii* Ihlen & Fryday, but *R. distinctum* can be distinguished from those species in becoming brown and in usually having fewer than eight cells per ascospore (Ihlen 2004, Fletcher & al. 2009).

Rhizocarpon sublavatum Fryday, Lichenologist 32(3): 214 (2000) Fig. 3

Thallus areolate, greyish brown, continuous, flat. Prothallus black. Medulla white, I–. Apothecia lecideine, black, round, 0.3–0.6 mm diam., sessile, concave; disc epruinose; exciple black, thick, usually persistent. Proper exciple dark brown, without crystals; epihymenium bluish green, K+ brighter; hymenium hyaline; hypothecium dark brown. Asci 8-spored. Ascospores colourless, eumuriform, 25–35(–37.5) × (10–) 12.5–15(–17.5) µm. Conidiomata not seen.

Chemistry—Thallus K–, C–. Medulla K–, C–. No substances detected by TLC.

Specimen examined: **CHINA. Sichuan, Luding Co.**, Moxi Town, Park. Hongshi, alt. 3060 m, on siliceous rock, 13 Oct. 2015, Weicheng Wang 20150660 (SDNU)

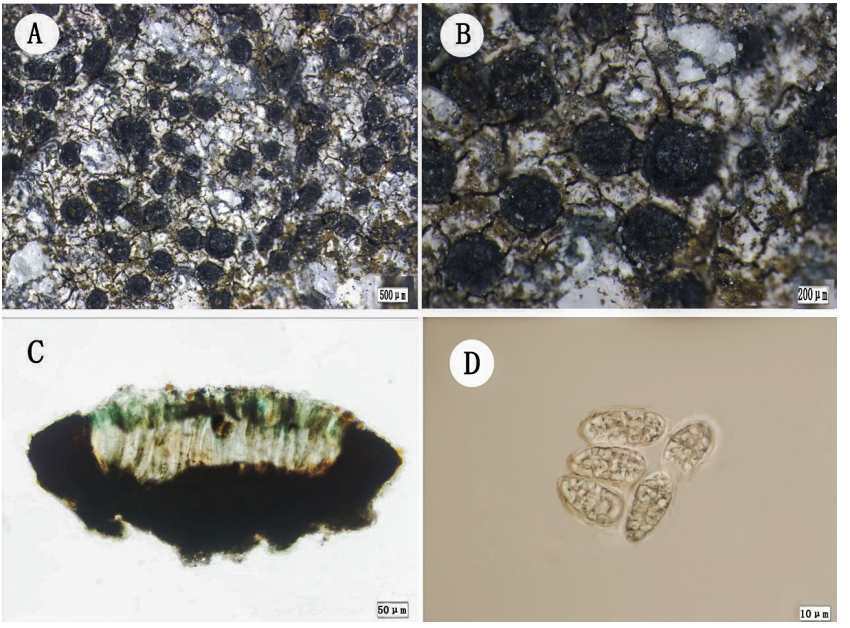

Fig. 3. *Rhizocarpon sublavatum* (SDNU – Wang 20150660). A: Thallus; B: Apothecia; C: Apothecium section; D: Ascospores.

Distribution—Great Britain (Scotland), Scandinavia, Iceland, and Central and Eastern Europe (Fryday 2000; Ihlen 2004). New to China.

Comments—Our specimen agrees with the type description, except that the protologue cites an effuse thallus and a flat to slightly convex disc (Fryday 2000). *Rhizocarpon sublavatum* is characterized by having smaller eumuriform spores than *R. lavatum* (Ach.) Hazsl., a bluish green epihymenium, and no lichen substances. The species shares a similar ascospore size and shape with *R. anaperum* (Vain.) Vain., which differs in a browner, more granular-areolate thallus, more highly branched paraphysoids, and a different apothecial pigmentation with only brown and grey pigments (Fryday 2000).

Rhizocarpon subpostumum (Nyl.) Arnold,
Verh. Zool.-Bot. Ges. Wien 27: 554 (1877) Fig. 4

Thallus areolate; areoles flat to slightly convex, polygonal to rounded, brown, epruinose. Prothallus indistinct. Medulla white, I–. Apothecia

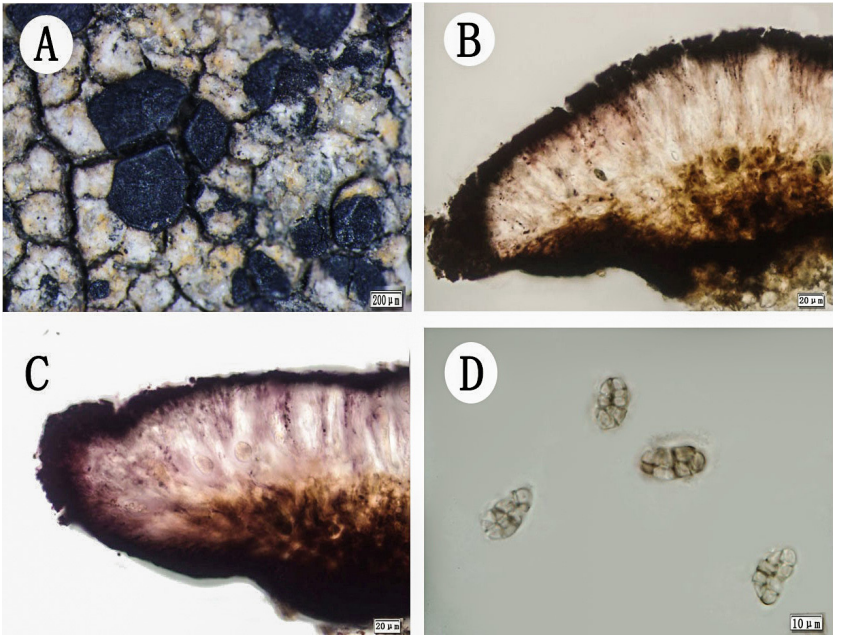

Fig. 4. *Rhizocarpon subpostumum* (SDNU – Du 20080268). A: Thallus and apothecia; B: Apothecium section; C: K reaction; D: Ascospores.

black, rounded to angular, 0.3–0.6(–0.8) mm diam., usually immersed, lecideine with a thin margin, flat to convex. Proper exciple dark brown, K+ purple; epihymenium dark green-black, K–; hymenium vertically streaked red-brown and K+ purple; hypothecium dark brown, K–. Asci 8-spored. Ascospores colorless, pale brown green when over-mature, submuriform, with a halo, 15–22.5(–27.5) × 7.5–12.5(–14) μm. Conidiomata not seen.

Chemistry—Thallus K–, C–; medulla K–, C–. No substances detected by TLC.

Specimens examined: **CHINA. Sichuan, Litang**, Mt Kazila, alt. 4700 m, on siliceous rock, 7 Nov. 2008, Yuanda Du 20080111, 20180268 (SDNU).

Distribution—*Rhizocarpon subpostumum* has previously been reported from Norway, Sweden, Finland, Iceland, Great Britain (Scottish Highlands), North America, and New Zealand (Ihlen 2004, Galloway 2007, Fletcher & al. 2009). New to China.

Comments—Our specimens conform to previously published descriptions. *Rhizocarpon subpostumum* is characterized by small apothecia, small submuriform ascospores, and the K+ purple exciple. It shares small apothecia and ascospores with *R. postumum* (Nyl.) Arnold, which is distinguished by its exciple not reacting K+ purple (Fryday 2000, Ihlen 2004, Fletcher & al. 2009).

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